Why, What and How to help each Citizen to Understand Artificial Intelligence?

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Abstract.

A critical understanding of digital technologies is an empowering competence for citizens of all ages. In this paper we introduce an open educational approach of artificial intelligence (AI) for everyone. Through a hybrid and participative MOOC we aim to develop a critical and creative perspective about the way AI is integrated in the different domains of our lives. We have built and now operate a MOOC in AI for all the citizens from 15 years old. The MOOC aims to help understanding AI foundations and applications, intended for a large public beyond the school domain, with more than 20000 participants engaged in the MOOC after nine months.

This study addresses the pedagogical methods for designing and evaluating the MOOC in AI. Through this study we raise four questions regarding citizen education in AI: Why (i.e., to which aim) sharing such citizen formation ? What is the disciplinary knowledge to be shared? What are the competencies to develop ? How can it be shared *and* evaluated? We finally share learning analytics, quantitative and qualitative evaluations and explain to which extent educational science research helps enlighten such large scale initiatives. The analysis of the MOOC in AI helps to identify that the main feedback related to AI is "fear", because AI is unknown and mysterious to the participants. After developing playful AI simulations, the AI mechanisms become familiar for the MOOC participants and they can overcome their misconception on AI to develop a more critical point of view. This contribution describes a K-12 AI educational project or initiatives of a considerable impact, via the formation of teachers and other educators.

1. Introduction

All citizens are impacted by digital technologies derived from computer science and this takes a new qualitative and quantitative turn with what is named artificial intelligence (AI). We *must* allow everyone to understand how AI mechanisms work in order to develop a critical and creative perspective towards digital technologies. For this objective, we develop a participative MOOC aiming to develop computational thinking competency and machine learning (ML) initiation. The MOOC initiative is inspired by the Finnish initiative to train 1% of its population on the AI domain [1], but also on the success in providing previous open access to computational thinking education resources for teachers and citizens not familiar with computer science. The AI MOOC we introduce in this paper is operated as a citizen training in AI in the broad sense, intended to a large public beyond the school domain, reaching more than 20,000 participants with a satisfaction level higher than 90% [2]. Through this initiative we aim to achieve an *ubiquitary citizen university in digital culture and digital sciences* [3].

Why (i.e., to which aim) helping everyone to understand artificial intelligence ? Most of us simply use it, do we need to understand how it works ? As discussed in [27] for kid initiation regarding AI, or pointed out in [23] at a societal level, and when introducing teaching resources such as [22] the need of "acculturation" is often simply settled as mandatory. This is also true at a more general level for STEM [26]. We agree, but it is worth making explicit the reason why. Let us point out two reasons:

- With the disruptive behavior of such AI mechanisms, one tends to personify such machines [9,28] or even put oneself down as "less intelligent" than the machine [23] : This could be a lever for domination (by humans) able to manipulate such systems, as opposed to critical thinking development (the notion is discussed in, e.g., [11]). Understanding AI can thus be considered as a mandatory (know-why) social skill. And we are going to observe that the main issue is related to "fear" : Being unknown and mysterious, AI was frightening, while thanks to this MOOC, "playing" with AI allows one to make these mechanisms familiar.
- Applications of these technologies seem endless in potentially all domains, at both an individual and collective level. We however can obviously consider that one will not be able to innovate without mastering the "how it works" [23,26] beyond using it as a black-box, because some key behaviors (e.g., adversariality [9]) are counter-intuitive and must be understood to avoid spurious usage. AI thus yields domain-specific knowledge (know-what) and technical (know-how) skills, which are mandatory.

A step further, while the two previous points intersect with all STEM, AI raises a specific issue: It questions also our vision[1] of *human* intelligence [9] by trying to model some cognitive human processes that are not restricted to computational thinking [12]. Current models of human creativity, for instance, can be questioned by AI models [29]. Moreover, when modeling some aspects of algorithmic intelligence, we are also advancing in a better understanding of human intelligence.

What to share regarding AI popularization is extensively discussed, for youngsters, e.g., in [27]. It is now well established, e.g., by Druga [18] that starting to "play" (i.e., experiment with and "program") with such a system allows one to develop the know-why, know-what and know-how skills pointed out previously. Available adult formations are more technical, as e.g. with Element of AI [1,25] which is now a worldwide reference in terms of AI popularization, or are simply "talking about" AI. We however consider that there is a lack: Adults also need to "play" with AI mechanisms to deconstruct misconceptions and construct pertinent representations of the underlying mechanisms, as proposed here.

How to share such know-why, know-what, and know-how skills is also already widely reported (see again [27] for an inventory of existing resources for youngsters, and [25] for a general positioning of our proposal with respect to the two other major resources). Here the key point is that we consider, following [24], a MOOC with game based learning components, dedicated to citizen formation as developed in [19] for another subject. Our pedagogical approach is in link with social learning, and promoting engagement as studied in [16] : Active learning including unplugged activities (see, e.g., [14]), promoting peer interactions, proposing "take-away" reusable resources, this with a clear problem-centric learning objective.

In order to report how we answered these three questions, we are going first to explain our position sketching what is to be shared with everyone and then to detail more concretely in link with 21st century skills what is proposed in this formation, before presenting the method and results and discussing perspectives.

2. Artificial Intelligence and the 21st century skills

As introduced, AI initiation of everyone is a key regarding what is called 21st century skills[2] as explained in Fig.1 and developed in [12]. With respect to this disruptive technology we need *critical thinking* to make the distinction between beliefs and effective tools, *computational thinking* skills to understand how it works in order to understand what happens when using it, *problem solving* capability to interact with these objects at the application level, *creativity* to develop and create our own usage of AI mechanism (and not only undergo the imposed uses), and *collaboration* because all this can not be managed alone.

[1] People often focus on "does AI yield machine intelligence" which is an ill-posed question as discussed in our supplementary material, whereas the fact machines execute what is considered as intelligent calls into question what is human intelligence.
[2] https://en.wikipedia.org/wiki/21st_century_skills

Fig. 1. A schematic representation of 21st century skills, from https://margaridaromero.me with permission, see supplementary material Fig.1bis for a detailed description.

Wondering how a machine would learn to solve such a complex task, comparing natural and artificial intelligence is also a great opportunity to ask how we, humans, could solve "mechanically" a complex task, a very interesting way of thinking in a reflective way how a human brain can solve it systematically. This is in direct link with computational thinking [12], and this aspect is highlighted in the proposed formation.

We detail in the supplementary material the learning objectives of the formation and develop how it is implemented. Let us simply highlight our specificity: With respect to other offers in the field [1], the content is less technical (e.g., machine learning programming in Python is proposed only as an extension), but not only a verbal introduction, while effective activities, including unplugged activities (i.e., without a computer using low-tech everyday tools), are proposed to understand how-it-works. We not only address AI at the conceptual level but the learner is engaged in practicing with different programs to learn the fundamentals of AI. As an example, in Fig.2, we summarize the level of technical explanation given for an activity using the http://playground.tensorflow.org interface, where participants are invited to build and train their own small deep neural network to solve a categorization task, while other activities with images or sounds are proposed, learning by doing.

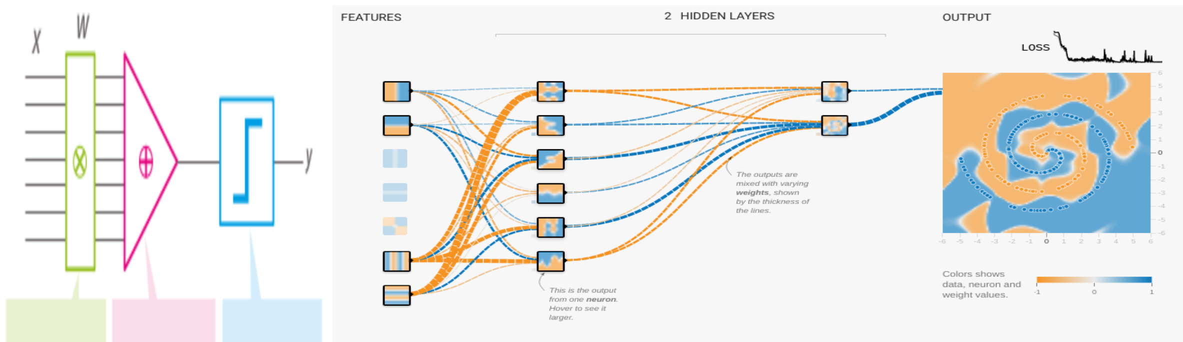

Fig. 2. The level of technical explanation of the "how-it-works". Left: An elementary computation (e.g., predicting whether the person head is feminin or masculin) is implemented via a computation unit (i.e., neurons) taking into account several input data X (e.g., the hair length, face pilosity, mensurations, …), each up to certain weight W depending on their pertinence or robustness (e.g., pilosity more than hair length) and combine then before providing an output y, based on statistical adjustment. Right: Combining many computation units in layers (i.e. deep-network, when many layers), allows to realize complex robust computations (e.g., face recognition or categorization) providing that all information has been "put in numbers" (i.e., quantified), with results that can be interpreted at a semantic level by humans. Images re-edited from https://pixees.fr and https://playground.tensorflow.org.

This formation has primary targets and secondary targets: The primary targets are “science outreach mediatory actors” (*médiateur·e·s scientifique*, in French), involved in AI K-12 initiation, while many citizens (e.g., parents of K-12 pupils) used this MOOC in order to transmit what they learnt.

An important aspect is the fact that all materials are open resources, in the sense of [17]. Beyond publishing under a CC-BY licence, and considering the different aspects of Open Educational Resources (OER) as reviewed in [20], we share our resources at different levels, enriching the link between OER and MOOC as stated in [21], with three aspects. *Granularization*: Embedded in a scenario, our resources are also modular and have been indexed and re-edited in order to be integratable as components of other scenarios, thus with suitable documentation to reuse the proposed bean. *Contamination*: One lever of the formation is the “teach to learn” paradigm, i.e., invite the learner to share her or his new skill in order to consolidate it, thus making the resource bean not only “open” but also easily reusable at the level reached by a person finishing the formation. *Collaboration*: The formation is not only “asynchronous” but also used in hybrid (online or in real life) synchronous sessions, raising another challenge: Not only reuse the resource, forking some resource if needed, including merging to enhance the resource, but also take the opportunity to have a common use of the resource to collaborate as in Class´Code [4], in a given (geographical or online structural) territory.

3. Learning by doing through concrete AI related activities

Each of the three chapters of the course is illustrated by concrete activities that bring learners to train their own machine learning models and interact with real life applications of AI.

For the first part of what artificial intelligence is, participants develop a first understanding of AI through training a visual recognition neural network model. In order to frame the activity, we designed an integrated tool to control the training of the model. This experiment is sequenced in three steps. In the first step the learners create a model that differentiates between two categories of images by feeding the model images from a dataset of samples given to them. This first step helps dispel preconceived ideas we have noticed in children with whom we did this activity such as the idea of an AI is a robot that can recognize anything in an image. They are led to realize that the AI they have trained can not recognize categories it was not trained on by testing it on images that do not represent one of the two categories known to the AI. In the second step the children understand that with few examples the machine learning model struggles to generalize the concepts represented by the images by testing it on images that match one of the categories but in a different context or position (a drawing of a lion instead of a photo of a lion for example). The last step is making them train a model on their own dataset with the classes and examples they choose and find.

The second activity around how AI is developed aims to highlight the central role of data in the making of machine learning applications through experimenting with biases in datasets. We have created a dataset of images with two categories: women and men with an obvious bias (women have long hair and men have short hair). After training a first model with this dataset and seeing it fail, the participants are then invited to reflect on the wrong inferences and create their own dataset to train a better model. They select data, train their model, test and iterate until they're satisfied with the result. Then, to emphasize the importance of data, participants are invited to build datasets to train machine learning models to recognize subjective categories, for example "cute cat vs ugly cat" and thereby understand the responsibility that fall on the humans creating AI's and the importance of questioning the data behind the AI applications they might encounter.

The last part about the interactions between AI and humans is illustrated by a series of activities where children experiment with real life AI applications. They are first exposed to painting generated by a Generative Adversarial Networks model and the painting made by a human painter the model was trained on. They are asked to try to differentiate the human paintings from the AI generated paintings. Then they get to modify the YOLO (You Only Look Once) model using a camera based real time image recognition model. They finally interact with a chatbot. These activities aim to broaden their understanding of the applications of machine learning and question how they can help humans.

4. Method and Production

Contents allow us to gain a first understanding of what AI means and what it is not, understand the principles of machine learning and the crucial role played by data, taking into account the societal issues of AI. Learners are invited to question themself, beyond preconceived ideas, and really understand the ground of AI; perform activities and manipulate AI programs to build their own vision; acquire a minimal scientific and technical culture (concepts, history of humans and ideas). As an outcome they are able to discuss the subject, question applications, choose some framework to contribute to the development (or not) of AI applications:
- *Questioning*: Deciphering the discourse around AI to move from preconceived ideas to questions on which to rely to understand.
- *Experimenting*: Perform activities and manipulate AI programs to make up our own mind, with both online and unplugged activities [11].
- *Discovering*: share a minimal culture, scientific and technical, to become familiar with concepts through the history of humans and their ideas.
- *Appropriating*: being able to discuss the subject, its applications, its framework with various interlocutors to contribute to the construction of AI applications.

We produced a *hybrid, participative, performative and contaminating* training:
- Freely accessible online training course with free of charge attestation of attendance; online exchange forum, to share and help each other, when training on these subjects; online and in real life hangouts to extend this sharing and serve local projects on these subjects, all content items being also reusable to derive and build other resources.
- Hybrid : Because online resources are designed to derive *in situ* activities. As a consequence, there are no "time limited sessions" but people join when they want and return when they need.
- Participative : In the sense that not only "scientists and engineers" with professional video and content producers have co-created the resources, but also "end-users" such as teachers or parents, while the content is adapted considering the participant feedbacks, including new resources creation (a kind of "wiki" where participants provide their input via forum messages and we take care of the shaping).
- Performative : Because students are taught to be their own teacher, while helping each other, and we also consider "how to learn to learn" mechanisms (e.g., find some answers on the web, discover some elements by themself during problem solving activities).
- Contaminating : Because students are invited to "pay" for this course by … sharing the contents with people from their surrounding.

Nothing "new" here, just the fact we not only propose a xMOOC "course" but also dedicate enough time resources to discuss with the participants, beg external person to contribute when needed, and do not restrain our participation to "our" MOOC but are willing to export also some resources or dialog into other initiatives of the same kind (e.g., driven by https://www.reseau-canope.fr or other https://classcode.fr partners), i.e., not only "with us" but also "at the others", using an approach known as cMooc [16].

This formation is hybrid and each chapter is illustrated by activities that bring learners to train their own machine learning models and interact with real life applications of AI, as detailed in the previous section. The formation is also performative and contaminating in the sense that an adult benefits from this training and then in his-her family or in his-her business, association, structure shares what s-he has discovered with his or her children or the seniors, or the other way round. Part of the training exercises is to be able to transmit what has been learned. Which is also a good way to learn. In Fig.3, we show such an activity that can be redone with family or friends.

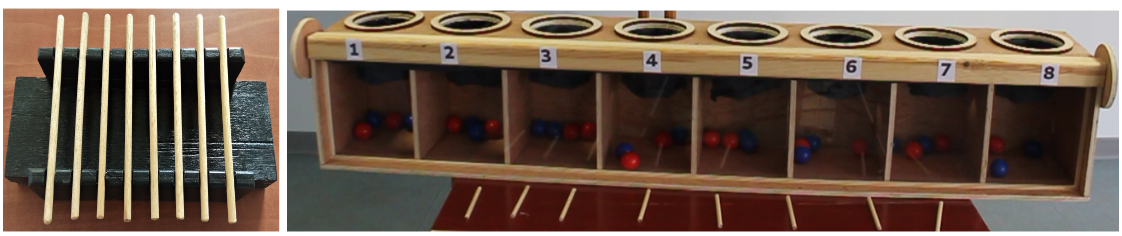

Fig. 3. Left: The “Nim game” is a simple strategy game in which two players (here a human and the “machine”) take turns removing (or "nimming") 1, 2 or 3 objects (here rods), the loser making the last nimming. This setup allows us to understand what an algorithm is (including algorithmic recursivity). Right: This “AI” machine is made of “balls and bowls” (or any equivalent objects). Each box corresponds to the number of remaining rods. The machine is “trained” by just putting a red or blue ball, depending on the game issue (win or lose), in the bowl corresponding to each move. After training, the whole game policy is stored in the “machine” and the artificial player just has to choose what to play, counting the balls in the corresponding bowl. This allows us to understand what is called “reinforcement learning”, and why a mechanism can “learn” a non-trivial rule (in fact, “always leaving a multiple of 4 rods”), without understanding anything. Images from https://pixees.fr as open CC-BY resources.

Regarding unplugged activities, it is often said that we should limit screen time, avoid digital passivity, and develop critical thinking about the digital world. A paradigm exists in which neither hardware nor software are required: unplugged computing (see [11] which has an English version as supplementary material for details). During unplugged or computerless activities[3], we learn concepts, often by playful activities to develop computational thinking competence [12] as a way of solving problems, in which computers are not the end in themselves. Unplugged computing activities have the advantage of not requiring costly equipment or the skills to operate it, relieving the cognitive cost to invest to make them work, allowing us to concentrate on the content. It is also the best proposal for so-called “contaminating” activities. In artificial intelligence initiation, it has also the major advantage to demystify and unpersonify the machine.

Concretely the resources (as exemplified in Fig.4) are made of short videos freely reusable, synthetical texts, quiz to auto-evaluate what has been shared and also to find by yourself some elements, activities online to manipulate machine learning algorithms via graphical interfaces, and unplugged activities to be performed in the family, with friends or in educational contexts (as exemplified in Fig.3); such activities are designed to be also realized by youngers (typically K6 - K12). At last, a mind-map, peer-to-peer corrected, is proposed in order to summarize what has been learnt via such a key-word graphical representation. A step further, the forum is an important tool: quiz questions are discussed (some of them have been improved after the first answers), and notions are re-explained or re-formulated, up to the point of enriching the core resources with re-writing of shared information: the goal for this citizen formation is to be improved by citizens.

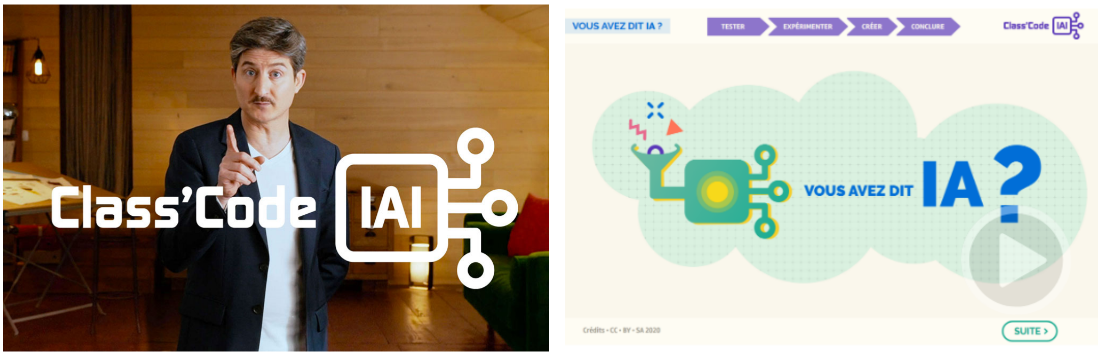

Fig. 4. Two examples of open reusable resources. Left: One thumbnail of the videos, based on a 3 to 4 minutes dialog between Guillaume, who is the “citizen”, and a researcher. She answers the question, gives some explanations, and invites him and us to question, experiment, discover and discuss each topic. Right: An example of the first screen of an interactive animation, guiding step by step to the discovery of a content, and some manipulation. The key point is that these resources are modular in order to be reused in other courses developed by the teachers (in the wide sense) using this resource for their formation. Images from https://classcode.fr/iai as open CC-BY resources.

[3] During unplug activities, the learners can take a step back, embodying [13] their learning through activities involving movement. It aims to develop a socio-critical approach through which the learner and citizen develops a critical and creative relationship with digital technology, appropriating the concepts and processes of computational thinking with their entire mind and body. The positive impact of these activities was studied, for instance by Brackmann and his colleagues [14] on two classes with a control group; they observed a statistically significant improvement in the children’s performance in computational thinking, for example, breaking down problems into sub-problems.

5. First Results and Analysis

After three months of activity, more than 13000 persons have been engaged in the AI MOOC (37% female, 62% male, 1% not binary) with more than 1600 persons active (answering to the first quiz) and about 600 persons having completed the full MOOC.
Even if the MOOC massively reaches a French public (79%), the African public is also well represented (Morocco : 4% ; Senegal, Tunisia, Cameroon, Ivory Coast : 1%). In all, 51 countries are represented.
Participants are mainly active (52% on activity, 14% retired, 12% students, 8% job researcher), mostly at university level (62% at least master degree in any field, 10% PhD), but rather beginners in the field (59% full beginners, 38% intermediate non expert).
Working time is 10 to 20 hours on average (about 50% of the people spend from 2 up to 5 hours per week, during about 3 weeks, while 25% spend less and 25% more), and above 94% of people having their expectation satisfied (43% fully satisfied), and 82% of them state that they could recommend this MOOC.

These statistics come from a start-of-course (1140 respondents) and end-of-course (217 respondents) surveys completed anonymously by participants on a voluntary basis. We should note that there is a bias in this survey since it is expected that it is people who are really invested in MOOC, and probably - as a result - the people with the best track record, who responded. This survey was presented as a tool to listen to participants' opinions, allowing us to know them better and improve training over time.

On the forum, more than 500 persons have been or are active while more than 3100 are reading, and there are about 370 discussions, more than half being on the course contents (e.g., strong versus weak AI, symbolic versus numeric methods, societal issues, …). More than 10 online hangouts of 30 to 200 persons have been organized already by one of the 70 partners of the Class´Code project [4], during this covid-19 confinement. Several pieces of this resource start to be reused to build other resources, e.g., to enrich textbooks[4] and their digital supplementary material.

Detailed evaluation results are given in the supplementary material of this paper, leading to following analysis.

Qualitatively, beyond very nice and encouraging positive feedbacks, through the constant evaluation of the course by the users, we are invited to take several improvements into account: (i) extend the existing formation with more operational tutorials, (ii) manage some technical weakness because we integrate state of the art recent external resources, some still to be consolidated, (iii) complete the existing contents to better help the learner progression. And we will, since this is a long term open course (probably more than 2 years). We have also a several questions on application domains of AI (i.e., in education, regarding democracy governance, or disabled assisting tools), which are a bit beyond what we can offer in reasonable time, because each third party domain requires a lot of prerequisites before considering AI related tools. Our idea is to offer "plugins" to other courses, i.e., participate regarding AI issues, the first project already in preparation being on GreenIT. For all these considered extensions, the present course acts as the core curriculum.

Qualitative observations, reading the different participant feedbacks available in our open data set, confirms our hypothesis that citizens now have a better understanding of AI. As pointed out, the main feedback is related to "fear" : Being unknown and mysterious, AI was frightening, while "playing" with AI allows one to make these mechanisms familiar. At the end, apprehensiveness is still present but regarding the human use of AI, not about "the" AI itself. Another shift concerns technophoby versus technophily. At the end, we did not notice than people "changed their mind" but all of then were more "technocritic", i.e., considering that the true answer is in the middle. A step further, several feedbacks concerned the fact "it does not always work": We have several pertinent observations from people noticing how easy it could be to defeat the estimation, not because the algorithm was "wrong" but because the performances were limited,

[4] For instance, one of us is also co-author of a "science" textbook for French K11 and K12, the AI initiation being included in the curriculum of this school teaching.

and easily biased by the training data. Regarding soft-skills we have no counter-example at the end of the course of people still "personifying" AI mechanisms, but these persons may have left the course if too far from their a-priori convictions. We are not able to really evaluate to which extent the know-why skills really improved, but can easily report participants to have generally the feeling they did. Regarding know-what skills, asserted by quiz answers, we have pretty good results, it is clear that this part of the formation has been successful, with one reservation: Our participants were mainly relatively well educated persons, as detailed in the appendix, thus were expected to succeed, regarding knowledge acquisition or consolidation. We also have no precise evaluation of what has been "discovered" (versus already partially known or well known) but can feedback about several persons "surprised" by a part of what they found. Regarding the know-how skills, the situation is contrasted and depends whether or not people did have time to invest in the activities. If yes, results are really good and participants came back with a request to "go further on". This is in favor of our assumption that this formation may be a gate towards more technical initiation such as [1,25]. All together, we can only affirm that self-evaluation and peer to peer evaluations lead to good results, and to witness that participants have the strong feeling to have a better understanding of AI.

A few participants did not find what they expected, either because they are not interested in redoing activities with young people (of any age ;)) to better understand or because they were looking for professional formation. In fact, we mainly reached rather highly educated persons, while we target popularisation, which seems to be more the case now, but slowly. In both cases, when a person joins, the content is always considered as accessible, and useful ("good to know"). The hard point is thus convincing yourself to join. We hope that in real life hangouts and also community approaches will help, and work on this aspect [5,6].

On our side, we are really delighted to participate on these researcher-citizen exchanges and shares, with very interesting questions, sometimes on crucial subjects, always kind and moderated (no troll[5], yet ;)).

We also better understand the real educational needs regarding AI foundation and applications. People clearly first want to clarify their belief about such a topic, understand what is true, what is coming and what is putative only. They then want to link such knowledge with concrete applications, e.g., what can be done regarding visual or audio processing, or not. This was easily covered for generic applicative tools, this is less easy to address for specific domain applications (e.g., justice or medicine) because this strongly depends on many other specific aspects of how it can be used. They finally are generally surprised but then highly convinced that they must "play with it" to build their own correct representations, and are rather proud to succeed.

With respect to other studies on MOOC engagement the present success seems to be related, as expected, to the "important role that instructors, course resources and pedagogic practices that focus on providing problem-centric and active learning play in engaging online students" [16] yielding good behavioral, cognitive and affective engagement, even if the didactic objective is specific but rather wide (here "understanding AI" with respect to, e.g., learning a given programming language), while peer interactions were really poor. Further studying this engagement, as performed in, e.g., [16] is a perspective of the present work.

6. Conclusion and Perspectives

We have reported on a citizen AI formation, detailing the pedagogical choices (linking everyday life elements to fundamental concepts, understanding the "how it works" via online or unplugged concrete activities, making explicit how understanding the "science underneath" allows to better discuss the societal

[5] We only got a bitter exchange about the fact we are very strong on gender equality, e.g., using inclusive writing (i.e., expliciting both male and female genders in French writing). Gender equality issues are especially important in the present context, and are omnipresent in our resources. This has been considered as "too much" by one participant, while several did support our choice.

impacts) and the pedagogical method.(e.g.: small conceptual videos, contaminating activities to be redone in real life, …).

We may consider our offer as the "grown up" counterpart of what is usually proposed to kids [18,22,27], i.e., a more accessible gate for non technophile targets, as an intermediate step before courses allowing the use of AI at work, such as [1,25], and as an alternative for more superficial presentation of AI only in "words". It seems to cover a real need, as quantified in section 6, and our goal is to really multiply the audience, either within the MOOC itself or by contributing to other initiatives, thanks to the openness of our resources.

Regarding AI-K12 education, our experience (including for other connected formations of Class´Code, such as [2] reviewed in [3]) is that such a MOOC is not directly usable as it. It has however three usages: (i) it allows the formation of the teachers in the wide sense (including parents, through family activities). (ii) it provides also reusable resources for these learners to prepare activities. (iii) several modular beans of resources (videos, interactive animations, self-contained texts) of the MOOC can be exploited by K8-K12 persons in an autonomous way. Building a "MOOC for youth" is another challenge, probably to be designed on the basis of game based learning MOOCs as studied by one of the co-author [24]. Examples (unpublished yet) of escape games involving STEM and including AI aspects, that seem to work well have been reported to us. It is a perspective of our work [30]. The need for the educators to gain a scientific and technical culture before deploying learning activities, was the first priority.

This "popular education" initiative is a contribution to the idea of a "*ubiquitary citizen university in digital science and culture"* [3], i.e., the fact that, beyond schooling, our society has a real need of "formation throughout life". And this is something that must be participative, performative and contaminant, in the sense developed in section 5, contributing to everyone's 21st century education in the sense reviewed in section 3, regarding AI competencies and beyond.

As next steps, we are going to invite a MSc student to deeply analyze the available learning analytics in order to better understand how to pursue (for at least two years) this initiative. We also are going, within the https://www.cai.community project, to further work on the online community aspects, targeting teachers (we must make a choice in terms of community), and this will drive us toward not only considering teaching AI, but also teaching the way to teach AI, including using AI frameworks (both symbolic and numeric) to better model the human learning process.

And for those who still believe that AI will generate a dystopia or some utopia, we will carry on explaining that this is neither wrong nor true, but a belief (anyone is free to have his or her own belief), and the best way to clarify, see go further, such belief, is to understand intelligently artificial intelligence.

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Availability of data, material and code availability: All resources are available under CC-BY or CC-BY-NC-SA licences and the platform software is open-source under the CeCILL-C (a French declinaison of the GNU-GPL).

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7. Supplementary material: Detailed presentation of 21st century skills.

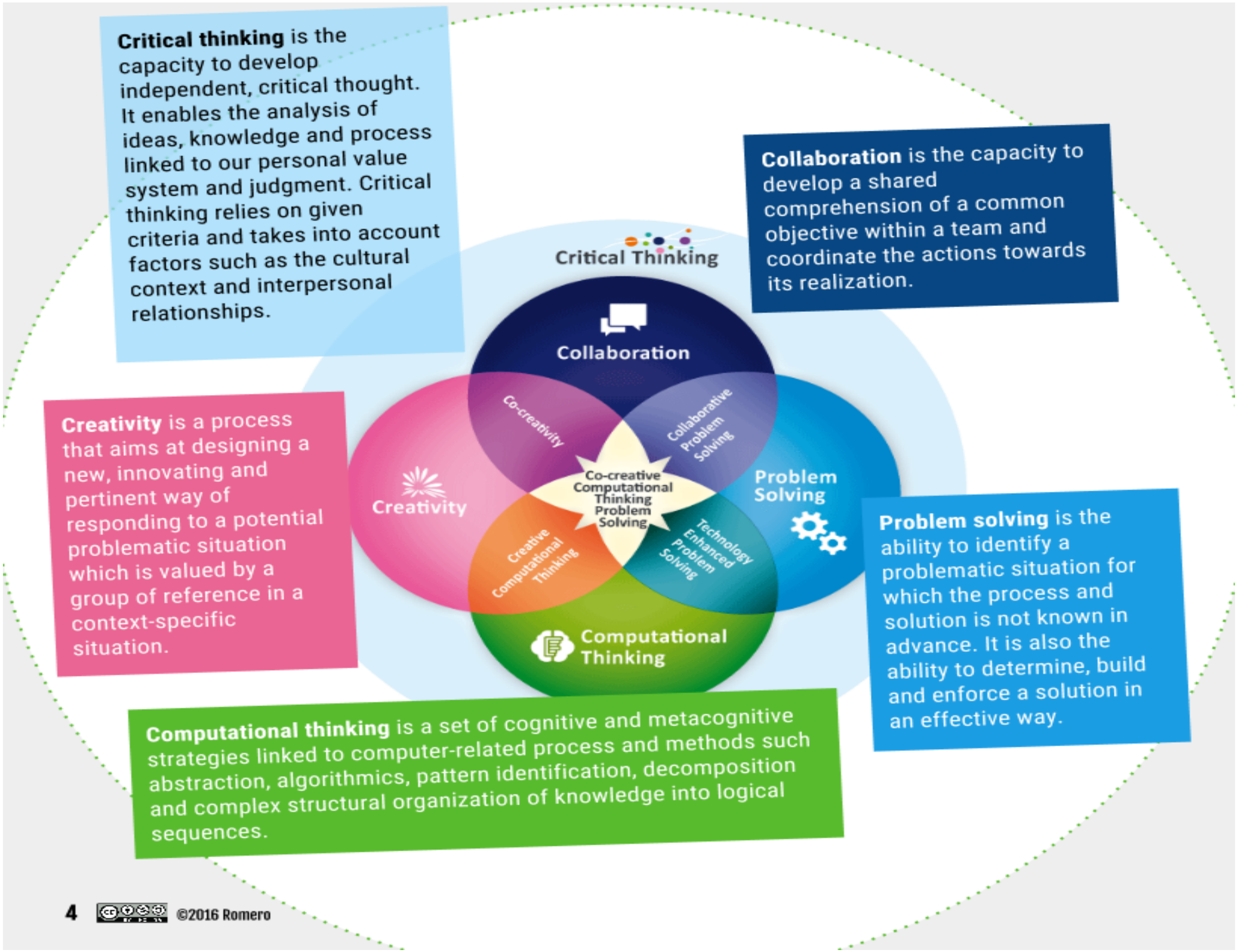

Fig. 1. A detailed representation of 21st century skills, from https://margaridaromero.me with permission.

8. Supplementary material: Understanding intelligently Artificial Intelligence.

Artificial Intelligence is "the science of making machines do things that would require intelligence if done by [human]" (Marvin Minsky 1968). This definition is very interesting because it does *not* address the issue of whether a machine is "*intelligent*[6]" or not, which is an ill-posed question [7], but defines a mechanical process *with respect* to (what we consider as) human intelligence. On the contrary, the emergence of AI mechanisms question what we consider as intelligent, for a human intelligence. Do large mental arithmetic skills demonstrate human intelligence ? A century ago, the answer was crealy yes, to the point of proposing public performances, while pupils were heavily trained, and mental calculators were in great demand in research centers. Nowadays pocket or smartphone calculators make the job and we know it is mainly the mechanical application[7] of algorithms. The fact is that not only numerical calculations have been mechanized, but complex symbolic operations manipulating symbols and relation between symbols (so called, "symbolic" AI) and also complex numerical processes (so called, "numeric" AI) yielding mechanisms to transform speech to text, categorize and or locate objects in pictures, and so on, up to implementing high-level specific cognitive functions algorithmically.

What is to be learned ?

Three key-points have to be made explicit :

- Firstly, very efficient transformation mechanisms (e.g., speech to text read out[8]) can be realized without "understanding a word" of what is said, being able to process information does not mean that information makes sense.

- Secondly, implemented methods, especially in symbolic algorithms (e.g., symbolic calculation[9]), can be in total disruption with respect to the corresponding human mental processes.

- Thirdly, it is generally accepted that the more specific the task is to solve, the most efficient the algorithm will be, "general" problem solver[10] cannot in theory be performant [8].

We consider that sharing such epistemological ideas is crucial to help everyone build an unbiased vision of what is called AI.

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[6] https://en.wikipedia.org/wiki/Intelligence

[7] Including non-intuitive sophisticated ones such as https://en.wikipedia.org/wiki/Trachtenberg_system

[8] Regarding speech-to-text, it appears that our speech decomposes in a few units of sound that distinguish one word from another in a particular language (phonem), about 50 (11 to 141 depending on the language). They form words (we use about 1000 to 3000 words daily, among 10000 to a bit more that 50000). In other words, the combinatorial is not that huge, and the fact that speech-to-text systems now work pretty well, detecting phonemes and using powerful and complicated statistical modeling systems, mainly demonstrates that "read out" does not require to "understand" the speech. Interesting enough, and contrary to image recognition, the speech-to-text systems architecture does not borrow much from our understanding of the corresponding neurophysiological processes. Furthermore, "brute force" statistical calculations surpass sophisticated signal processing approaches.

[9] A lot of mathematical algebra is now performed using algorithms of "computer algebra", so that mathematical engineers delegate most of the calculation to the machine, concentrating on reasoning and concepting. The key point is that the computer algebra mechanism can be very far from the human treatment of the same problem (e.g., polynomial factorization is performed over finite fields of increasing cardinality and not using rewriting rules as a human would do). Furthermore, this requires completely different skills, such as understanding symbolic algebra, reformulating the problem in an algorithmic way, interpreting the result or non result. A step ahead, the disruption is even greater with theorem prover and program formal validators.

[10] The contribution of the so-called "no free lunch" theorems is that it tells us choosing an appropriate algorithm requires making assumptions about the kinds of target functions the algorithm is being used for (introduce as much a-priori information as possible), whereas with no assumptions, no "meta-algorithm", such as the scientific method, performs better than random choice.

In order to develop a critical and creative agency towards the way AI is changing our society and everyday life, these new tools that deeply change our society and everyday life, it is also important to understand "how it works". We now learn creative programming at school, and this is the lever for understanding the digital world. Based on this scientific culture it is easy to explain the difference with AI mechanisms:

Regarding numerical AI, the system is "programmed by the data". Very general algorithms with a lot of parameters can implement very specific but different functions by adjusting these parameters on a training data set (either explicitly when supervising the training, or more implicitly when either providing a positive or negative reinforcement reward or adjusting the parameters on the data set structure without supervision). Programming paradigm consists of designing an architecture with suitable algorithmic modules, setting up a learning process and feeding it up with data. This is the case for numerical data or symbolic knowledge. This explanation illustrates the technical level chosen to explain AI mechanisms to everyone.

A step further, believing that a machine can be built to be (or to become by itself) "globally intelligent" is neither wrong nor true: It is a *belief* [9], and we are all of us free to believe (or not) this could or will happen. Furthermore, when considering this notion of intelligence, the concept is often mixed with the notion of *intentionality*[11] or *self-awareness*[12]. This belief is a recurrent human myth[13], but also a scientific assumption[14] of "global AI feasibility", that has driven years of research, without concrete achievement on the main subject itself, but very fruitful side effects [10]. Understanding AI is also a way to develop *critical thinking* in relation to the field of AI, as discussed in the next section.

Implementing these learning objectives.

At a more concrete level the formation curriculum has been organized in three sections.

- *What is artificial intelligence?* In order to gain a first understanding of what AI means and what it is not, including historical aspects. One pedagogical key point here is to insert between human intelligence and machine intelligence, animal intelligence, i.e., compare natural and artificial intelligence. Such an approach is not the most frequent, but really helps to think differently about AI. A real place to symbolic AI (e.g., formalization of knowledge, e.g., for the semantic Web) is also given, not only because it is an important domain, regarding the applications, but also because it helps to better understand how we humans can formalize our knowledge. The reasons why we can be frightened (or unboundly optimistic) by AI is also discussed.

- *How to develop artificial intelligence?* Here, machine learning and data programming is introduced, without mathematics, but detailed enough in order to understand the principles of machine learning and the crucial role played by mastering data sets. Care is taken to explain all the abscons words (e.g., "deep learning" ? simply the fact a large number of calculation layers is pipe-lined from the input at the bottom to the output on the top (thus yielding a *deep* architecture) is used to obtain a compact calculation). As detailed in the next section, all notions are discovered "by doing" through activities.
A large part of the section is devoted to data, their uses, the related risks (e.g., privacy, bias) always explaining how it works, to allow each of us to construct her or his own vision and opinion.

- *Artificial intelligence at our service?* Beyond the scientific and technical aspects, this section aims at better understanding the issues and the levers, in order AI to really be at the service of people. Beyond

[11] https://en.wikipedia.org/wiki/Intentionality
[12] https://en.wikipedia.org/wiki/Consciousness and https://en.wikipedia.org/wiki/Qualia

[13] In a nutshell, the notion of "human machine", that slavish works for us (untill uprising), starts with slavery where humans are reduced to machines, and many ancient mythologies, and most modern religions include artificial people (e.g. golems, Pinocchio or the Frankenstein' creature), while automata already exists in ancient civilizations before nowaday modern "robots" (from "robota", i.e., forced laborer).

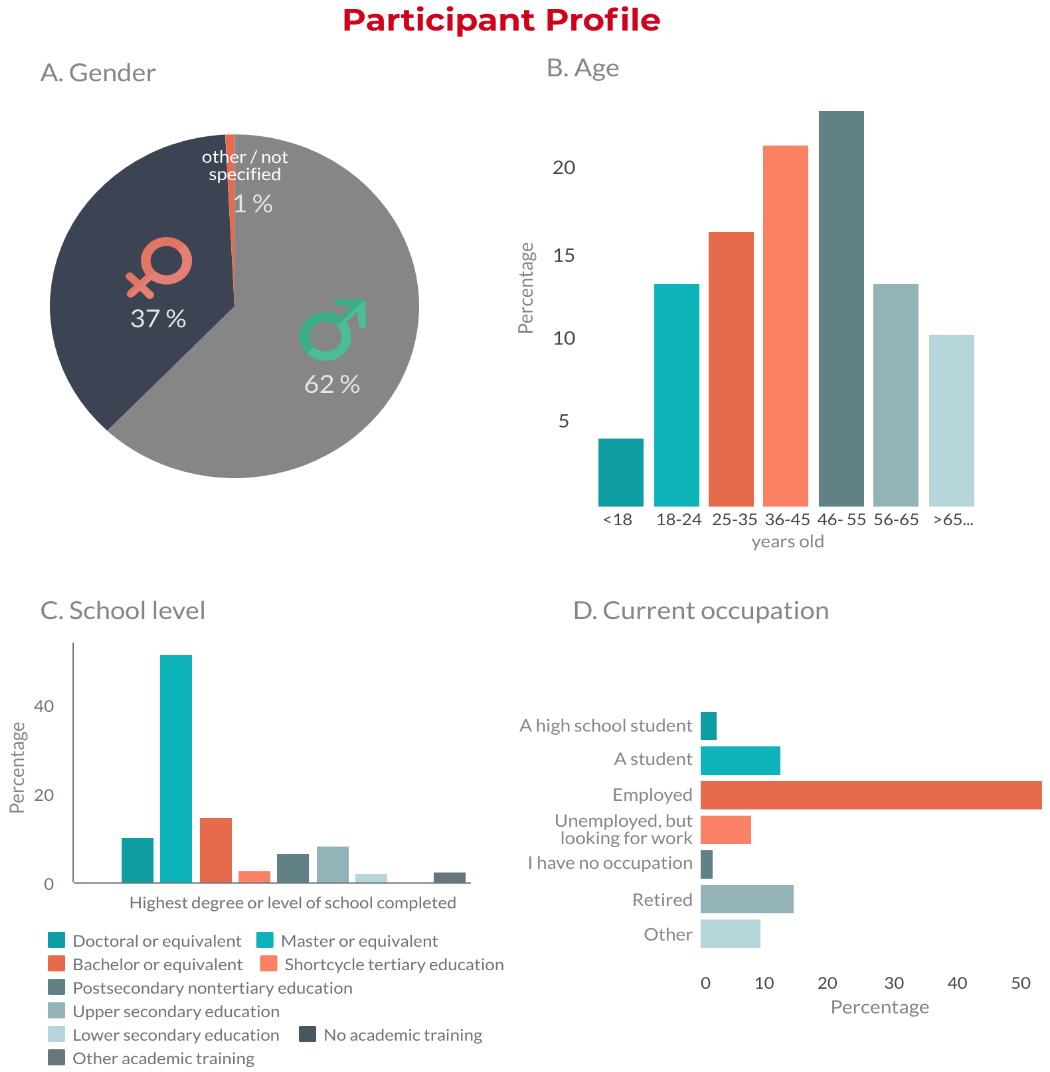
[14] To be entirely exact, the correct falsifiable scientific assumption is "global AI cannot exist" and the research objective is to refute this assumption. What is called "AI winters" [10] is not simply a defeat of the "global AI" dream, but an "epistemological break" in the Gaston Bachelard sense, allowing the emergence of actual powerful scientific productions.

myths and rhetoric manipulation[15]. Attention is paid to make the distinction between what is already there (even if we do not notice it), what is coming, and what is hypothetical. The better understanding offered by the two previous sections makes really sense here. Some applications are detailed, some others are to be … invented. The question is also raised about when we do *not* need AI.

[15] Let us illustrates these two aspects by a saying “if a AI robot with AI beats you, be sure that, “hidden” behind, a human takes advantage” as explained in [9], GAFAMs are act as “pyromaniac firefighters”, who launch great debates on very hypothetical aspects of artificial intelligence while they impose, from now on, disruptive algorithms of artificial intelligence, without any discussion. Another aspect is some “rhetorical shift”: For instance, we discussed a lot of autonomous vehicles (which obviously will not work after a great craze due to hazardous media ads), and while we waste time discussing "the dangers or benefits of autonomous vehicles” we miss asking the real question “do we need autonomous vehicles or are there other transportation emergencies?”.

The autonomous vehicle already exists: to avoid any risk it is run on specific tracks, to facilitate driving we put guide rails, to save energy we make collective vehicles, they can even drive automatically, it carries a name: it's called a train.

9. Supplementary material: details on the evaluation result



10.

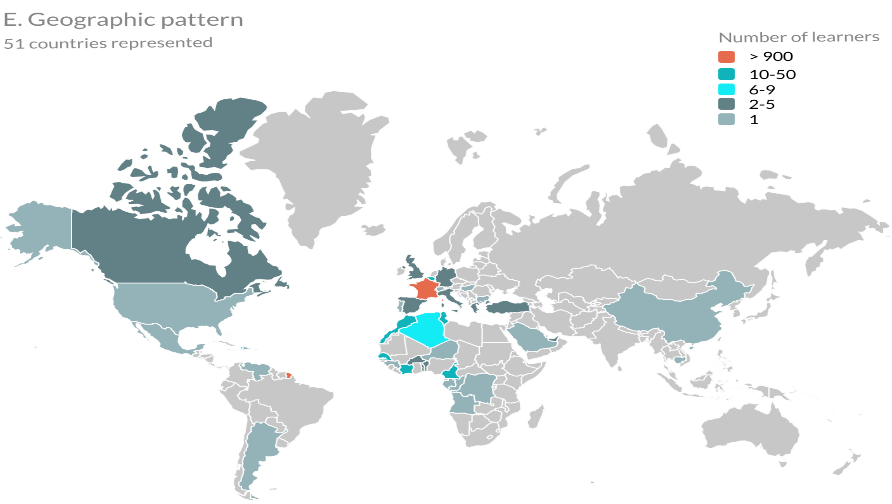


Fig. 1. Participant Profile. A. Gender ; **B.** Age ; **C.** School Level ; **D.** Current Occupation ; **E.** Geographic pattern. *Statistics come from a start-of-course (1140 respondents) survey completed anonymously by participants on a voluntary basis.*

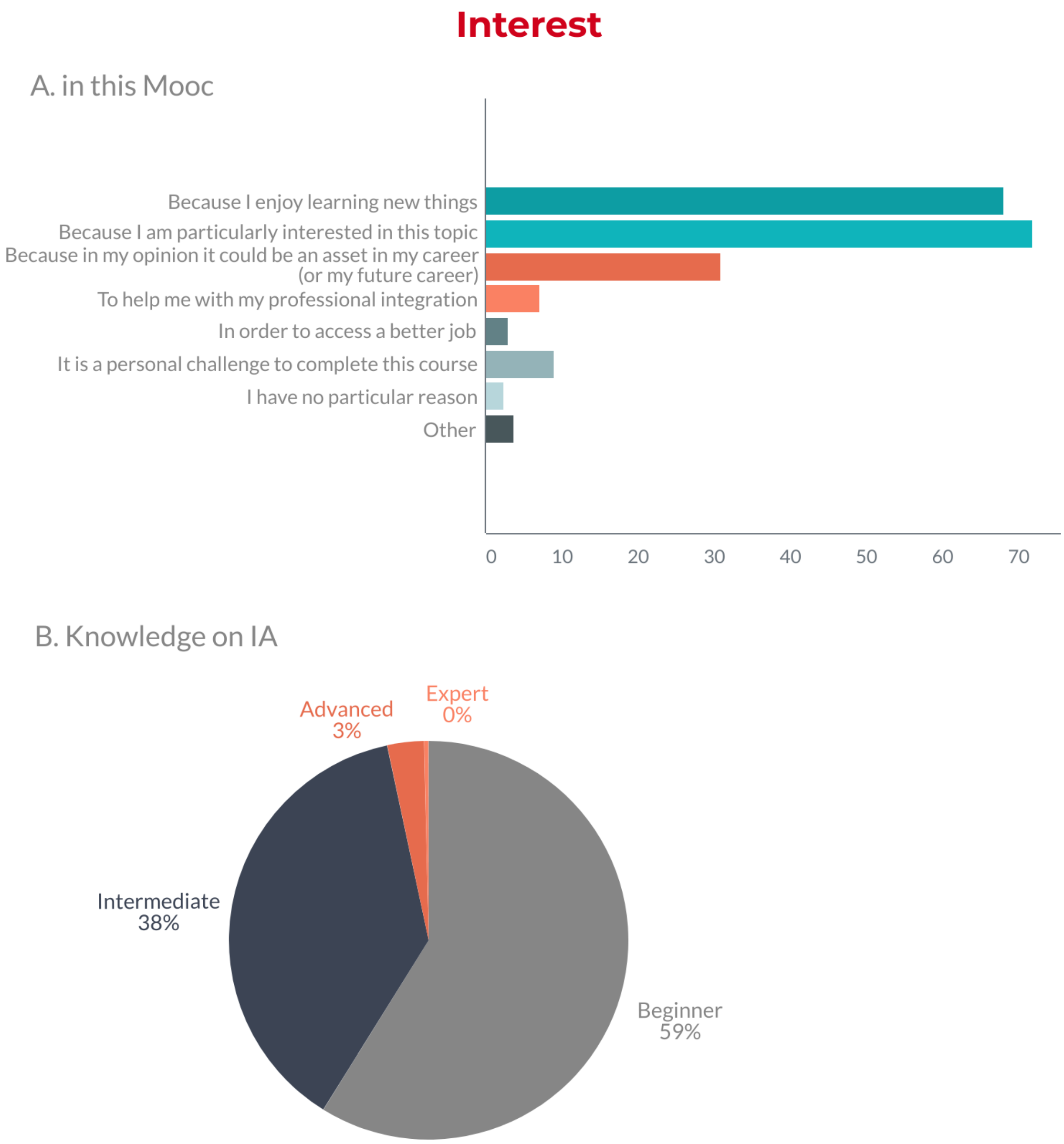


Fig. 2. Interest for the MOOC and AI. A. Interest in the MOOC ; **B.** Knowledge on AI. *Statistics come from a start-of-course (1140 respondents) survey completed anonymously by participants on a voluntary basis.*

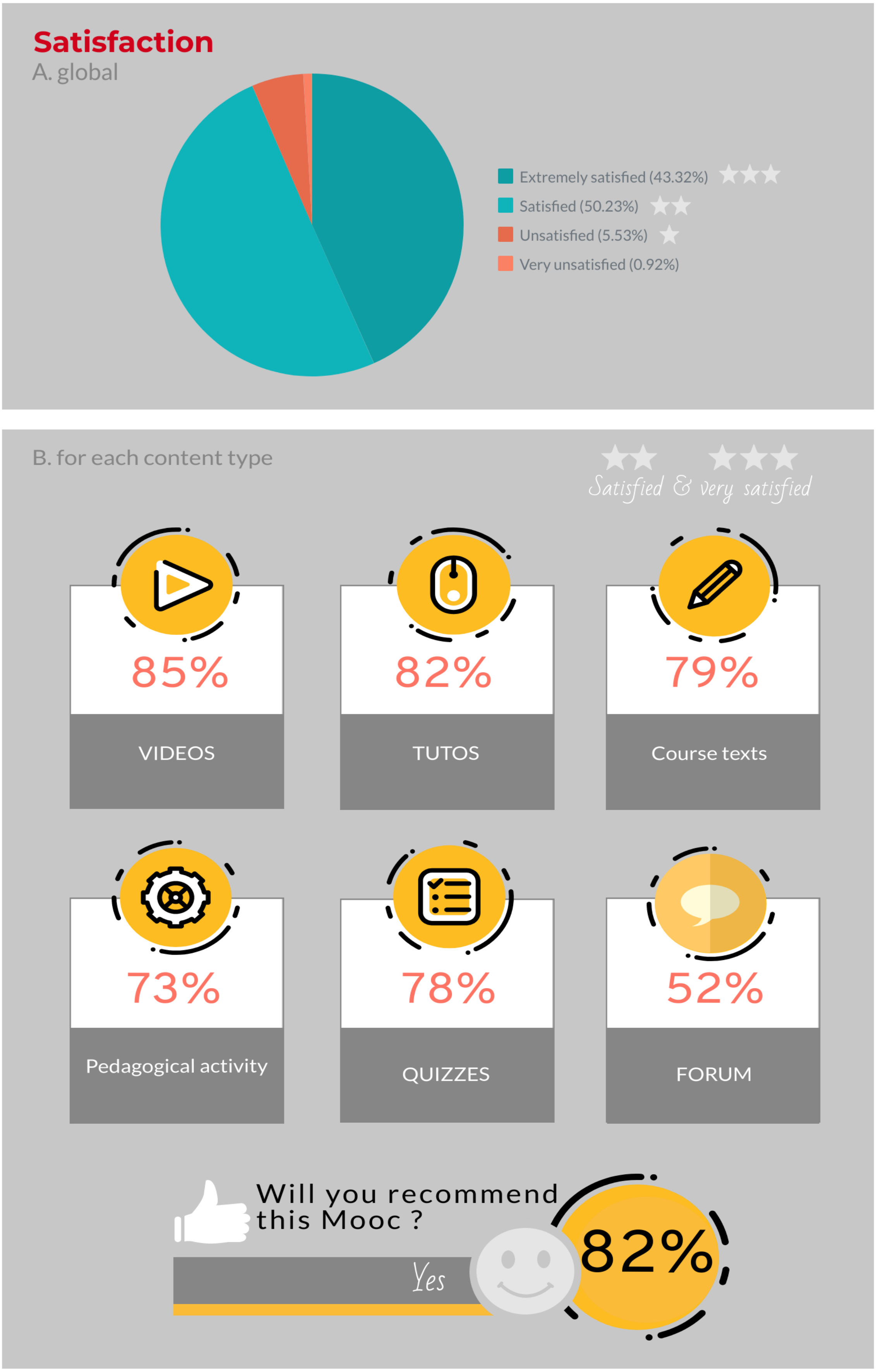


Fig. 3. Participant Satisfaction. A. Global ; **B.** For each content type. *Statistics come from an end-of-course (217 respondents) survey completed anonymously by participants on a voluntary basis.*